Description of Groundwater Conditions at the Former Martin Marrietta Reduction Facility, The Dalles, Oregon

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CDM Smith

Section 1
Introduction

This document is a summary of the current understanding of the hydrogeologic framework at the Former Martin Marietta Reduction Facility CERCLA site located in the City of The Dalles, Oregon. Information presented at the meeting between Lockheed Martin Corporation (LMC) and the Environmental Protection Agency (EPA) on March 26, 2013 is included along with a copy of the presentation from the meeting.

The site has a long history of groundwater investigations and monitoring since the early 1980s that have been used to formulate descriptions of the site hydrogeology. A groundwater evaluation was conducted and documented in the Remedial Investigation and Feasibility Study (RI/FS) completed in1988. Additional monitoring wells were installed after this time period as part of the post-closure activites for the RCRA Landfill. The studies conducted in 2008 – 2011 by Northwest Aluminum Company (NAC) are also considered in this summary. A summary of investigations is included in Section 1. Section 2 describes the conceptual groundwater model, including the extent of site related contaminants. Section 3 summarizes the site groundwater monitoring programs, while Section 4 documents potential data gaps and that should be considered for additional investigation and possible additional monitoring wells.

1.1 Summary of Investigations and Data Collection

Many studies and report have been prepared in the region describing the hydrogeology and groundwater supply potential that have provided background information to relate the Site to the region. Detailed groundwater studies have been conducted at the facility and have been documented in numerous reports. This section documents sources that have been utilized to develop the current understanding of groundwater at the site. The major sources of information are presented in the following sections.

1.1.1 Regional Groundwater Studies

Regional investigations of the geology and groundwater have been conducted by the U S Geological Survey, U S Army Corps of Engineers and the Oregon Department of Geology and Mineral Industries, principally associated with groundwater supply potential in the Dalles Groundwater Reservoir (DGWR) aquifer. These data are cited in the site-specific investigations described in the following sections. These regional studies did not address site contamination issues and predated the RI. The earliest investigation was conducted by Piper (1932), where the Dalles Groundwater Reservoir (DGWR) was identified as the principal aquifer in the area. Geologic mapping of The Dalles area was conducted by Sargent (1956). A 1981 study by Grady addressed basinwide groundwater characteristics to assess the declining water levels in the DGWR. The impact of tectonic structures on groundwater in the Dalles was assessed by Newcomb (1969). Bella (1982) presented a maps of surficial geology and structure in the area of The Dalles,

1.1.2 Facility Water Supply Wells

Four large capacity production wells completed in the DGWR aquifer were installed during plant construction in the mid-1950s. These high capacity wells provided the water supply for operations when the reduction works was in operation and continue to supply cooling water to the Northwest Specialties facility, which is still in operation. One of the wells was plugged and abandoned when process related constituents were detected in the well in the mid-1980s, since it was suspected that the well seal was not protecting the deeper aquifer. The three remaining production wells are still active.

1.1.3 RI/FS and RCRA Investigations

More than 70 wells have been drilled to characterize the Site since 1987 (Geraghty & Miller, 1988). In addition, monitoring wells to monitor what is now the closed RCRA Landfill were also installed and used in the RI/FS to develop the groundwater site conceptual model, which is the basis for the current understanding of the site. These studies and the description of the groundwater site conceptual model are thoroughly documented in the RI report, released in 1988 and accepted by EPA.

1.1.4 Ongoing Monitoring at RCRA and CERCLA Units

Implementation of the selected remedy in the ROD for the Site was completed in the early 1990s and the Site was de-listed in 1996 from CERCLA. Closure of the RCRA Landfill occurred in the early 1990s. Monitoring of water quality, water levels and leachate recovery rates has continued to the present day. Many of the monitoring wells at the site were plugged and abandoned in 1995 since they were not needed to monitor remedy performance and monitoring results showed concentrations were below drinking water limits. Results of groundwater monitoring are documented in the annual and semi-annual reports that have been issued since completion of the ROD implementation and closure of the RCRA Landfill. Additional documentation is provided in 5 year review documents that have been prepared by EPA or the Oregon Department of Environmental Quality (ODEQ).

1.1.5 NAC Demolition Investigations

The current site owner, Northwest Aluminum Company (NAC), conducted limited groundwater investigations to support approval of a no further action determination for the site during 2009 to 2011. This work included installation of four groundwater monitoring wells and sampling of these wells and building sumps. All wells have subsequently been plugged and abandoned.

Section 2

Groundwater Site Conceptual Model

The site conceptual model for groundwater (SCM) describes the aquifers, sources and locations of recharge and discharge, and the hydraulic properties of the significant units. Groundwater gradients and flow directions along with potential sources of contamination provide a basis to evaluate adequacy of site monitoring networks. Water quality information allows definition of transport pathways for site contaminants and potential receptors. The SCM was developed during the extensive investigations and monitoring that were conducted during the RI/FS and confirmed by the more than 20 years of monitoring data collected at the site. The physical framework for the groundwater system at the site is described in Section 2.1. Groundwater potentiometric surfaces are documented in Section 2.2 and contaminant distributions are provided in Section 2.3.

2.1 Site Hydrostratigraphy and Aquifer Extent

Groundwater at the site occurs primarily in fractured basalt and in limited sedimentary materials between individual basalt flows. There are small areas on the site where the irregular basalt surface has unconsolidated material filling depressions in the basalt surface where limited groundwater occurs. An alluvial aquifer with a limited areal extent is present north of the CERCLA Landfill and is associated with Chenowith Creek. The aquifers at the site are listed below and are described in subsequent sections. **Figure 2-1** summarizes the stratigraphic terminology from the regional literature and shows the naming conventions on the site for the bedrock aquifers. The studies conducted by NAC in the 2009 – 2011 period used different terminology for the aquifers, so their naming system is also provided on this figure. The aquifers of importance at the site include:

- Chenoweth Creek Alluvium
- Perched Aquifer (includes both unconsolidated fill and shallow fractured basalt)
- S aquifer
- A aquifer
- B aquifer
- DGWR aquifer

The sequence of flows within the Columbia River Basalt has been characterized in the regional literature and from site investigations. The Columbia River Basalts were emplaced as multiple individual flows, with significant periods of time passing between flows. These hiatus periods resulted in weathering, enlargement of shallow fractures, development of soils and deposition of alluvial materials on these surfaces. The hydraulic properties of the aquifers vary substantially depending upon the position within an individual flow. The dense interior of a flow is typically very low permeability due to the slower cooling that occurs, compared to the top and base of the flows, where rapid cooling occurs. These dense interior zones limit vertical connection between individual aquifers.

The upper and lower surfaces are exposed to rapid cooling and develop more fracturing leading to higher permeability, and may include the interflow deposits.

The regional understanding of site stratigraphy was confirmed using a deep corehole (MW-16D) and characterized using geochemical methods to determine the individual flows that are present. Drill cuttings from other wells installed during the RI were correlated to MW-16D to identify individual units. This information was used in combination with geologic mapping to assign aquifers within the regional framework. The shallowest basalt flow exposed at the site is the Lolo flow. The Lolo is separated from the underlying Rosalia flow by the Byron Interbed, which is an interflow zone that includes alluvial materials. The Rosalia flow is a complex flow that includes several dense interior zones that isolate individual aquifer units. The Rosalia flow is underlain by the Quincy/Squaw Creek interbed, an interflow zone containing a significant thickness of interbedded silt and sand, with a lignite bed. The Sentinal Gap flow is the deepest unit that has been investigated at the site. The core log at MW-16D indicated the following thickness for each of the units as:

- Lolo Flow 54 feet
- Byron Interbed 2.5 feet
- Rosalia Flow 141 feet
- Quincy/Squaw Creek 25 feet
- Sentinel Gap Flow >49 feet

Figure 2-2 presents a geologic map showing the surficial materials and structural features. A fault is present along the margin of the Chenoweth Creek valley that intersects geologic units present at the Site. Units on the south side of the fault are offset from those on the north by about 150 feet. This map also shows the extent of the Lolo Flow outcrop area, indicated by the contact with the Byron Interbed. Since topography drops off from the high area on which the plant was constructed, the Lolo Flow is truncated outside of this contact in the plant area. A gentle syncline or trough is present on an east west axis, passing through the southern portion of the plant site.

Each of the aquifer units is described in following sections.

2.1.1 Chenoweth Creek Alluvium

The Chenoweth Creek valley contains alluvial sand and gravel up to 60 feet thick, based on a well log from the animal shelter well that was plugged and abandoned during the ROD implementation. The alluvium occupies a valley up to 400 feet wide and appears to persist for a distance of about 3000 feet from the Columbia River. The alluvium includes a poorly sorted mix of cobbles, gravel, sand and clay. The alluvium was interpreted to be in contact with the S and possibly the A aquifer in the RI. The small areal extent of this aquifer limits its potential utility as a source of water supply.

2.1.2 Perched Aquifer

The Perched aquifer is a phreatic or unconfined aquifer that comprises the uppermost saturated zone at the site. The Perched aquifer consists of unconsolidated materials filling depressions in the bedrock surface and artificial fill in the former plant area. During the remedy implementation, soils in the cathode waste handling areas northeast of the plant and the unloading area south of the plant were excavated to bedrock. Shallow groundwater was removed during construction and significant inflows did not persist, indicating limited areal extent for the perched aquifer in this area. The saturated thickness of this fill or unconsolidated material was noted in the RI as up to 3 feet. Similarly, during removal of two small landfill cells in 2009 near former wells MW-8s and MW-9s, perched groundwater was encountered in fill or unconsolidated materials above the basalt, which was also depleted during dewatering.

A shallow perched zone is also present in the near surface basalts, as indicated by the inflows observed at the CERCLA Landfill leachate collection system (LCS) and by an abandoned dewatering trench located southwest of the CERCLA LCS. It is also likely that the shallow fractured basalt contributed water to the former dewatering sumps in the process buildings. This shallow perched fracture zone lies primarily in the upper 20 feet of the basalt and exhibits a higher water level elevation than the underlying S aquifer. Since dewatering flows did not persist in excavations of fill and alluvium, the degree of connection between the unconsolidated fill materials in bedrock depressions and the shallow fractured bedrock zone appears to be limited. The localized unconsolidated fill deposits are insignificant due to the limited areal extent and small volume of water. The shallow fractured bedrock zone is important, since it is the primary source of groundwater that is recovered in the CERCLA LCS. Limited information is available on this shallow fractured bedrock zone, since it was not investigated during the RI. Several piezometers near the abandoned dewatering trench are reported to be screened in this zone and will be evaluated for possible future sampling.

2.1.3 S Aquifer

The S Aquifer was the shallowest significant unit defined in the RI, where it was identified as an unconfined aquifer. Examination of drilling records from the RI, and from recent drilling at MW-42S and wells installed by NAC suggest that the S aquifer may be confined, since stabilized water levels are above the top of the water bearing zones noted during drilling. The S aquifer includes the lower portion of the Lolo Flow, the Byron Interbed and the upper portion of the Rosalia Flow. Differentiating the upper portion of the S Aquifer and the overlying fractured perched zone is difficult and the degree of connection between these zones is unknown. The S aquifer is bounded below by dense basalts in the flow interior. The S aquifer, where it is present, is typically encountered at depths between 30 and 60 feet. Saturated conditions were not encountered in the interval corresponding to the S Aquifer in wells located west of the former plant that were installed during the RI. The S aquifer is truncated by topography in areas downslope of the outcrop of the Byron Interbed on the east and south and does not extend to the Columbia River. The fault along Chenoweth Creek truncates the S aquifer to the north, where it subcrops against the alluvium. The hydraulic conductivity of the S aquifer is low and its limited areal extent make its use as a water supply aquifer impractical.

2.1.4 A Aquifer

The A Aquifer is located within a section of the Rosalia flow that was deposited in contact with a shallow water body. This resulted in development of pillow lava structure that has a higher hydraulic conductivity as a result of fracturing that occurs at the time of placement due to the rapid cooling while the lava was still flowing. The A Aquifer is present through most of the Site, however, the RI noted that it thins and becomes less permeable to the south. The thickness of the aquifer ranges from 5 to 45 feet at the site. The A Aquifer is truncated to the north by the Chenoweth fault and to the east where it is in hydraulic contact with the deep channel of the Columbia River. The A aquifer is bounded below through most of the site by a unit described as the lava lobe in the RI, which is a dense basalt up to 20 feet thick that cooled slowly, resulting in a lesser degree of fracturing. Where this lava lobe was not emplaced in the northern portion of the site, the A Aquifer likely merges with the underlying B Aquifer. This A Aquifer is capable of producing water at rates of up to 20 gpm.

2.1.5 B Aquifer

The B aquifer occurs in a pillow lava near the base of the Rosalia Flow. This highly permeable zone developed due to the rapid cooling and contact with water as the flow migrated along the Quincy/Squaw Creek surface. This aquifer is present throughout the Site, though it is truncated to the north by the Chenoweth fault and likely to the east by the deep channel of the Columbia. The B aquifer is hydraulicly connected to the Columbia River. The thickness of the aquifer ranges from 30 to 50 feet at the Site. The B aquifer can be a prolific producer, with yields in excess of 500 gpm possible. The B aquifer is partially confined below by the Quincy/Squaw Creek Interbed, which consists of cemented siltsone and sandstone, with a lignite. Laboratory testing of the interbed material reported in the RI indicate this unit is nearly impermeable.

2.1.6 Dalles Groundwater Reservoir Aquifer

The DGWR is the principal aquifer that is used for water supply in the area. It is located in the upper portion of the Sentinal Gap Flow and has a thickness ranging from 10 to 50 feet and occurs at depths greater than 200 feet. This aquifer is also likely truncated by the Chenoweth fault to the north. Wells in this unit are capable of yields in excess of 1,000 gpm. The water supply wells on the Site that are used for industrial operations are completed in this zone. The City of the Dalles used this aquifer extensively in the past, and currently uses their wells to supplement their primary surface water supply during times of low flow. The Chenoweth PUD has several wells completed in the DGWR northwest and west of the Site at distances of several thousand feet.

2.1.7 Aquifer Configuration

The configuration of the aquifers at the site is best illustrated using cross-sections from the RI, which were developed from the numerous wells that were drilled on the site. The deep core logged at MW-16D provided the basis for defining the site hydrostratigraphy, which was then used to correlate to other wells that had only drill cuttings available for logging. **Figure 2-3** from the RI and **Figures 2-4** through **2-9** provide a location index and a series of cross-sections illustrating the aquifer configuration at the site. Cross-section A-A' (**Figure 2-4**) is a north – south section that shows the alluvium and Chenoweth fault truncating the aquifers at the northern limit. This section also shows the impact of topography on the areal extent of the S Aqufier, since it is intersected by the topography at the southern end of this cross-section at the scrubber sludge ponds. The configuration of the aquifers is relatively flat-lying in the area of the plant, since the syncline which is encountered by this section is very subtle. **Figure 2-5** is a north south cross-section along the western side of the Site that shows the fault truncating the Site aquifers to the north. The southern limit of the cross-section remains on high topography, so the S Aquifer is still present. **Figure 2-6** shows and north to south section passing through the location of the former process buildings and the RCRA landfill, extending to the scrubber sludge ponds. This section shows the penetration of the process building basement into the perched shallow fractured zone and potentially into the upper portion of the S Aquifer. The topography truncates the S Aquifer at the southern end, as land surface declines toward the scrubber sludge ponds. **Figure 2-7** is also a north south section along the eastern portion of the Site which also shows the truncation of the S Aqufier. This section also shows the aquifers subtly rising in elevation toward the south. **Figures 2-8 and 2-9** show west to east cross sections extending from the upland areas of the Site to the Columbia River, illustrating the truncation of the S Aquifer by topography, and the A and B aquifer by the deep channel of the river.

2.2 Groundwater Levels

This section describes the observed vertical gradients and the configuration of the water table or potentiometric surfaces in each aquifer at the site. These gradients control the flow direction and in combination with the hydraulic characteristics of the aquifer determine groundwater velocities.

2.2.1 Vertical Head Differences

Vertical head differences at nearby wells screened in different aquifers allow interpretation of the potential for flows between the aquifers. The actual quantity of flow is a function of the vertical hydraulic conductivity of the materials separating the aquifers and the gradient. Vertical gradients at the site are typically downward, with water levels in deeper zones occurring at progressively lower elevations. **Figure 2-10** provides a cross-sectional view through the Site in a south to north direction illustrating the differences in water levels at several adjacent wells in different aquifers using data from the RI in 1987. Water levels in the S Aquifer are significantly higher than than the underlying A Aquifer, which is expected, since the S and A Aquifers are separated by a dense basalt with limited fracturing. Four of the locations on the cross-section include well sets with adjacent A and B Aquifer wells. In the northern portion of the site, well clusters at the MW-2 and MW-14 locations show water levels in the A and B units are similar. In the central portion of the site at the MW-16 location, the water level in the A Aquifer is significantly higher that that in the B Aquifer, suggesting a greater degree of isolation between the zones at this location. This is consistent with the interpretation that the lava lobe, which is present in this area, acts to isolate these zones. The water level in the DGWR Aquifer is similar to that observed in the B Aquifer, suggesting the two zones are in hydraulic communication. The MW-4 location shows the A and B Aquifers again have similar water level elevations.

2.2.2 Potentiometric Surface Configuration

Groundwater flow in the S Aquifer is shown on **Figure 2-11** for the March 2010 period. This period was selected since additional data were available from the NAC S Aquifer monitoring well. Groundwater flow in the S Aquifer is radially outward from high ground near the former process building location toward the northeast, east and south, generally following the trend of topography. This suggests that recharge is occurring in the area of the former process building and discharge occurs along the areas where the S aquifer is truncated by the Chenoweth alluvium or topography. The quantity of water potentially discharging is expected to be low, since no visible springs have been noted in past studies in the outcrop areas. The permeability of the S Aquifer is also low, which limits its ability to transport groundwater.

The potentiometric surface configuration for the A and B Aquifers relies on the comprehensive set of measurements in 1987, since few of the A or B monitoring wells remain at the site. **Figure 2-12** shows the A Aquifer potentiometric surface, illustrating flow toward the north and west. Recharge occurs primarily from the Columbia River, which is in hydraulic communication with the A Aquifer. Recharge will also occur in areas where the A Aquifer outcrops at the surface to the south of the Site. This map does not include the measurement from MW-16, which was anomalously high and was also not included in contour maps provided in the RI. **Figure 2-13** shows the potentiometric surface for the B Aquifer, indicating flow toward the west. Both the A and B Aquifer water levels were likely impacted by pumping in the DGWR from the plant industrial water supply wells, which would create a downward gradient and increase vertical leakage downward. The B Aquifer map also shows the impact of recharge to the aquifer from the river.

2.2.3 Water Level Fluctuations

Monitoring of water levels has been conducted at the site at varying frequencies since the RI. Frequent monitoring has occurred during the 1989 – 1992 period , with a lesser intensity after this period. During the 1993 to 2003, monitoring was primarily conducted on an annual basis. **Figure 2-14** shows water level measurement in the S Aquifer in the vicinity of the CERCLA Landfill over the period of record. Water levels in the S Aquifer show seasonal variability in response to recharge during the wet season, with no apparent long term trends in water levels, with the exception of MWR-8S. Well MW-8S may have been impacted by contact with the shallow groundwater and a questionable annular seal in the upper fractured basalt, and was plugged and abandoned when two small landfill cells were removed in 2009, and replaced with well MW-42S. **Figure 2-15** shows data from a corresponding period for the A and B Aquifer monitoring wells. These wells also showed the seasonal variation in water levels. This seasonal variability in the deeper aquifers is likely to be associated with variation in river stage and seasonal pumping of the DGWR Aquifer. The A and B Aquifers also illustrate the impact of the City of The Dalles moving to use of surface water as their primary supply in about 2000. Water levels have risen in the A and B Aquifers by about 30 feet since this change in pumping and now show a water level that is similar to the adjacent river elevation.

2.3 Water Quality

Water quality characterization has occurred throughout the Site during the RI and continued in the vicinity of regulated units since that time. The principal contaminants of concern at the site for groundwater include free or WAD cyanide, fluoride, and sulfate, based on monitoring results and the wastes that were generated at the facility. In addition, PAH compounds are present in soils and the scrubber sludge ponds, however, the high degree of sorption and nearly insoluble nature of these compounds limit their mobility and they were not detected during the RI in groundwater at the site. The ROD for the site identified alternate concentration limits (ACL) for fluoride and sulfate for the S aquifer as a performance criterion for the remedy, while MCLs or risk based concentratons were set as the criterion for free or WAD cyanide for all of the aquifers. EPA has indicated they intend to replace the current ACL performance criterion with MCLs for the S Aquifer.

Fluoride is the most extensively distributed constituent of concern at the Site. Extensive quantities of fluoride were used throughout the operating period of the plant, some of which was released to the environment either as solids to the soils or as dissolved phase from the air pollution control systems. Recent studies by NAC have identified areas where soil concentrations exhibited leachable concentrations of fluoride above the ACLs. Several areas near the former production building were located and remediated that contained fluoride concentrations in soil up to 22 percent. An area near the southern portion of the process building was docuemented by NAC to contain soils with leachable fluoride at concentration above the ACL, and was not remediated. In addition, concrete containing significant fluoride and leachable fluoride was disposed into the building foundations by NAC and is being allowed to resaturate with shallow groundwater. Data from the period 2000 through 2012 were summarized to define the probable extent of the fluoride in groundwater exceeding the ACLs and MCLs and this extent is shown on **Figure 2-16**. **Figure 2-17** shows the most recent available data for wells at the site for fluoride, which indicate that the ACL is exceeded only at a NAC well in the A zone. **Figure 2-18** shows the areas where the MCL for WAD cyanide is exceeded during the same period. This figure includes the S, A and B aquifers, though the exceedances are limited to the S Aquifer. **Figure 2-19** shows the recent data for sulfate, which has no exceedance of the ACL and only a single excedance of the secondary MCL at the NAC well in the S Aquifer.

Section 3

Monitoring Well Network

An monitoring network was available at the Site during the RI that was used to develop a understanding of the groundwater site conceptual model. After this system was understood, EPA approved revisions to the site monitoring programs to focus on the regulated units to verify remedy performance. Many of the wells installed during the RI that were below the drinking water limits were abandoned in 1995. The number of wells that have been used for characterization and monitoring over the last 27 years include the following:

- 25 S Aquifer
- 25 A Aquifer
- 18 B Aquifer
- 2 DGWR Aquifer

Wells that remain on the Site include the following:

- 17 S Aquifer
- 5 A Aquifer
- 2 B Aquifer

Figures 2-20 through **2-23** show the location of currently available and abandoned wells in the S, A, B and DGWR Aquifers.

Section 4

Data Gaps and Path Forward

Site characterization and groundwater monitoring has been conducted at the Site over the last 25 years, which has resulted in an understanding of the groundwater system, including groundwater flow and the distribution of contaminants of concern. Based on the recent review of the site database, several potential data gaps have been identified.

The first of the areas that may warrant additional characterization and monitoring are the shallow perched zone that is present in the upper approximately 20 feet of the basalt, particularly in the area of the CERCLA Landfill. This zone may be a source of inflow into the LCS and is currently not characterized or monitored. There are several piezometers present in the area of the abandoned dewatering trench in the southwestern portion of the CERCLA fenced area, however, no data on these piezometers have been located.

The second potential data gap relates to monitoring of areas east and downgradient of the scrubber sludge ponds and the former process area. Wells that monitored the shallow groundwater in these areas were abandoned with EPA approval in 1995 when they did not show any exceedance of drinking water standards. There has been no monitoring downgradient of the eastern side of the scrubber sludge ponds or the process area since then. Well MW-29s serves to provide monitoring data on the southern side of the scrubber sludge ponds and shows that the ACLs are met in this area.

The third data gap is associated with monitoring of the demolished former operating areas of the plant that are owned by NAC. Wells installed by NAC and subsequently plugged and abandoned, indicated the presence of fluoride and sulfate exceeding the ACL standards. NAC also created what amounts to a construction debris landfill by disposal of concrete containing leachable fluoride into the basement foundations of the former process building. This area is likely resaturating from inflows from the shallow groundwater system and surface recharge.

LMC proposes to prepare an annotated outline of an investigative program to fill these data gaps to serve as a basis for discussion with the EPA. It is anticipated that after discussions and development of a concensus with EPA that a detailed work plan with a sampling and analysis plan will be presented to the agency for approval. Certain areas may be difficult to obtain access, since these areas are not owned by LMC, and the assistance of the agency in obtaining participation of the current landowner may be required, especially considering their potential role in releasing contaminants to the environment through their operations and demolition activities.

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Figure 2-1 Hydrostratigraphic Column

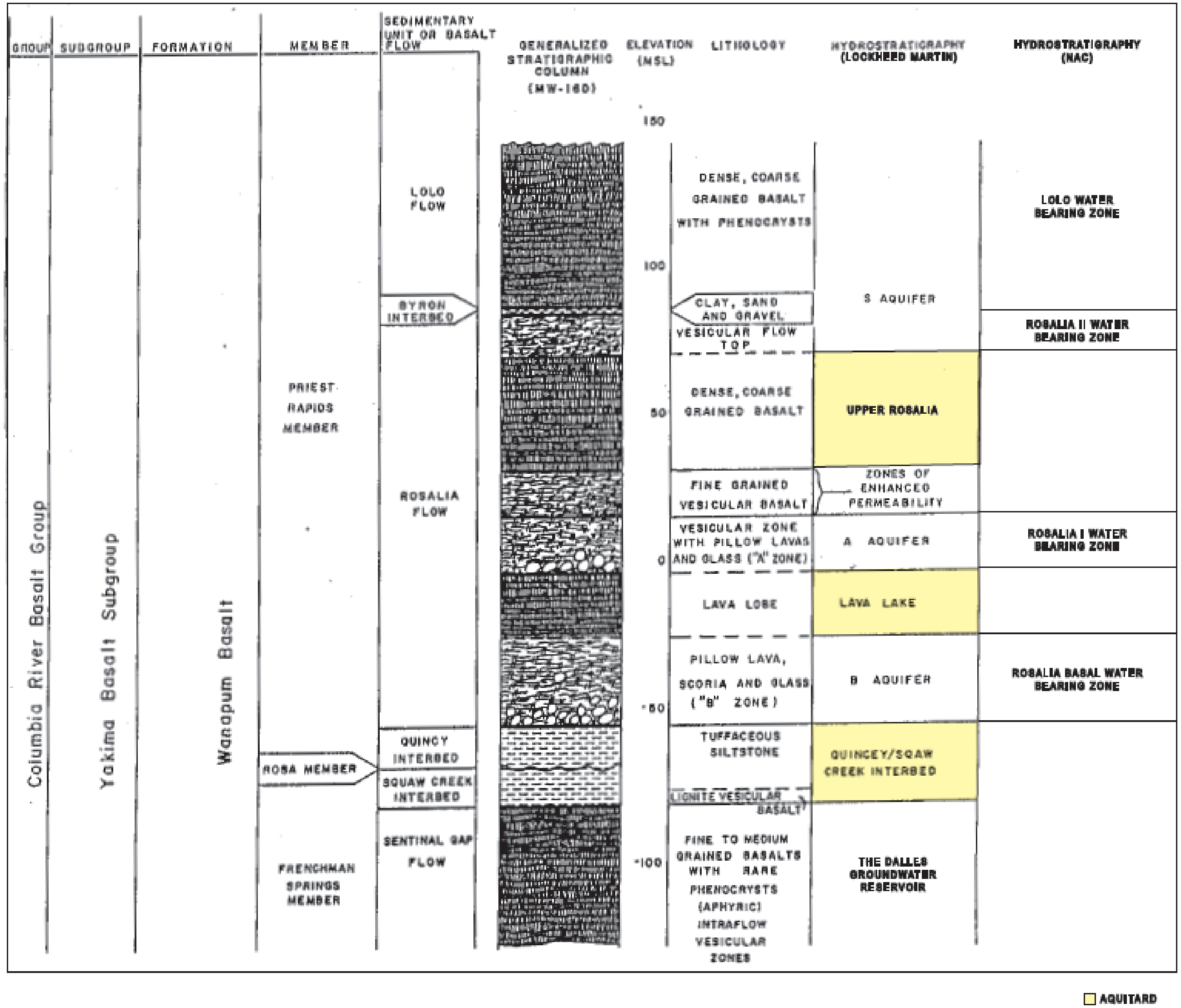


Figure 2-2 Geology and Structural Setting

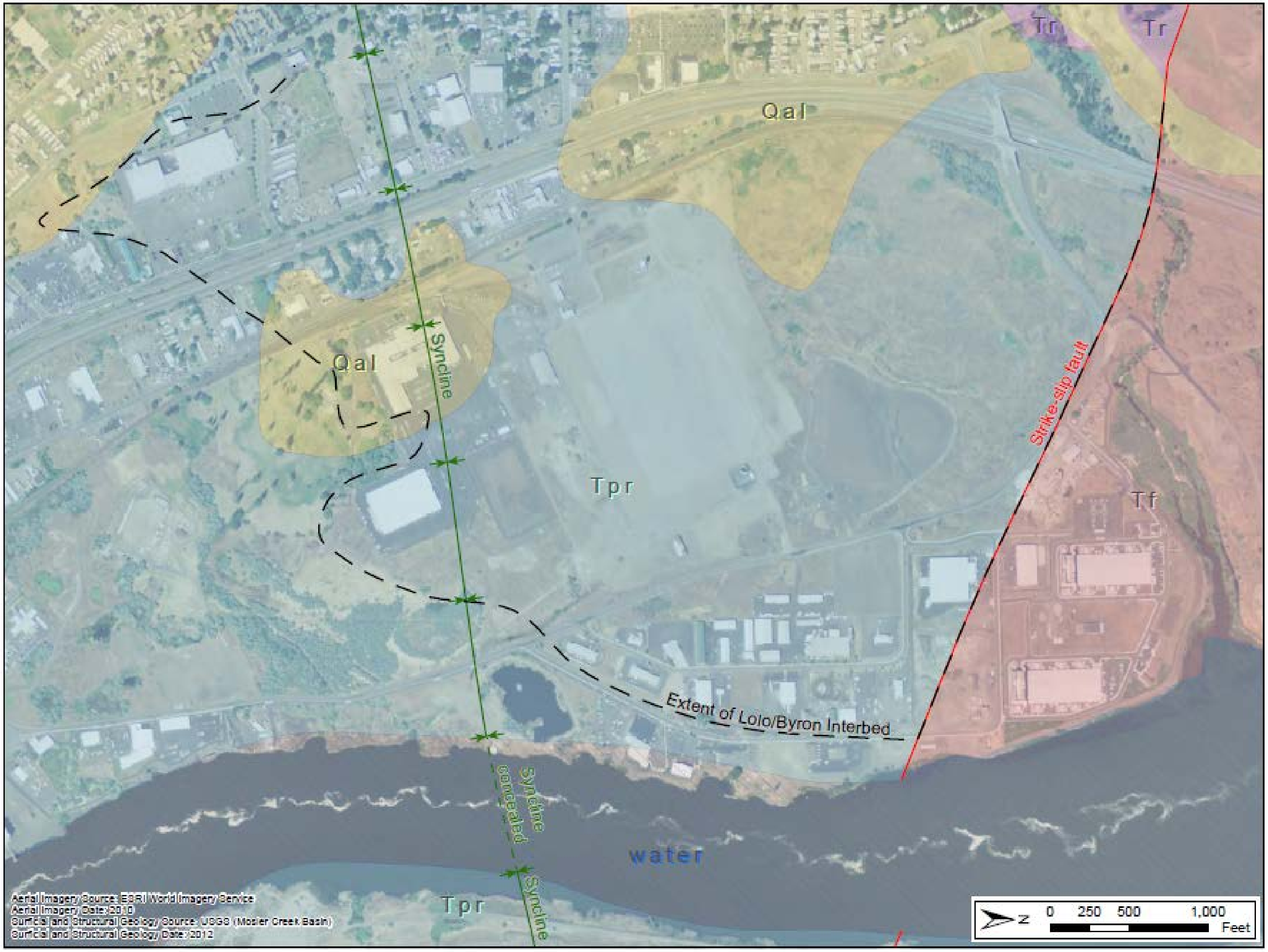


Figure 2-4 Cross-section Index Map

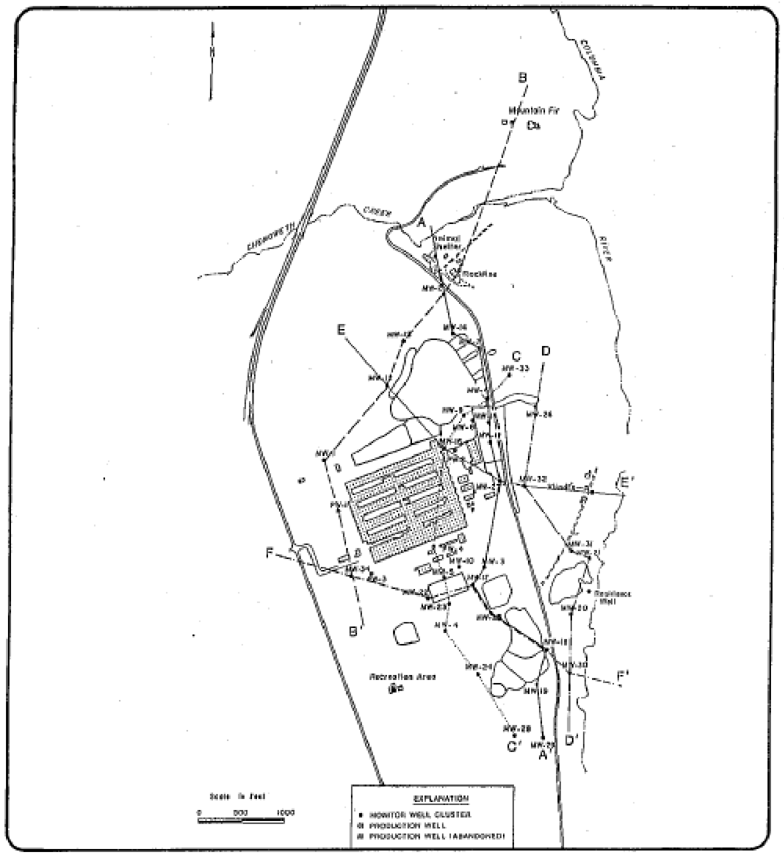


Figure E.3.1 Cross Section Location Map

CLIENT NAME:

Martin Marietta Corporation

Figure 2-4 Cross-Section A – A’

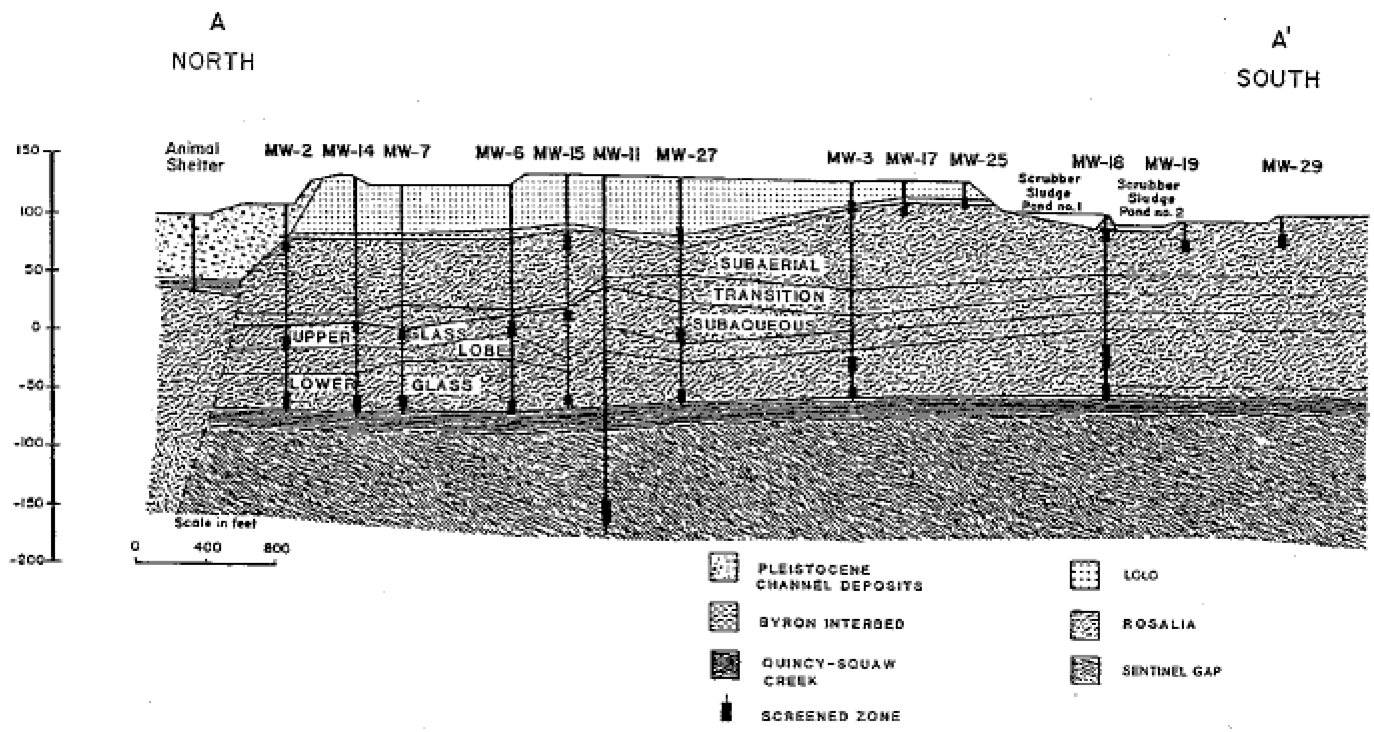


Figure 2-5 Cross-Section B – B'

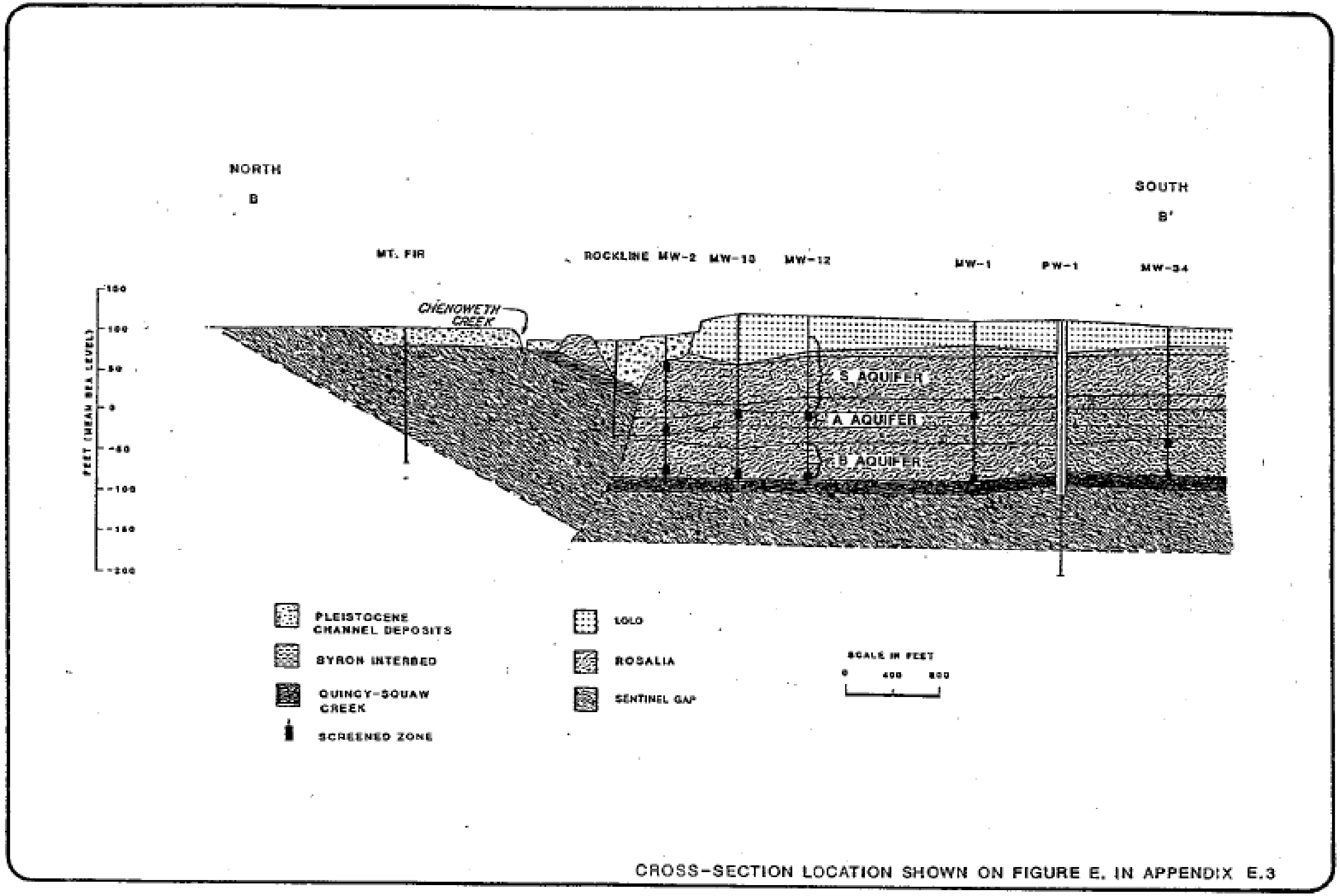


Figure 2-6 Cross-Section C – C’

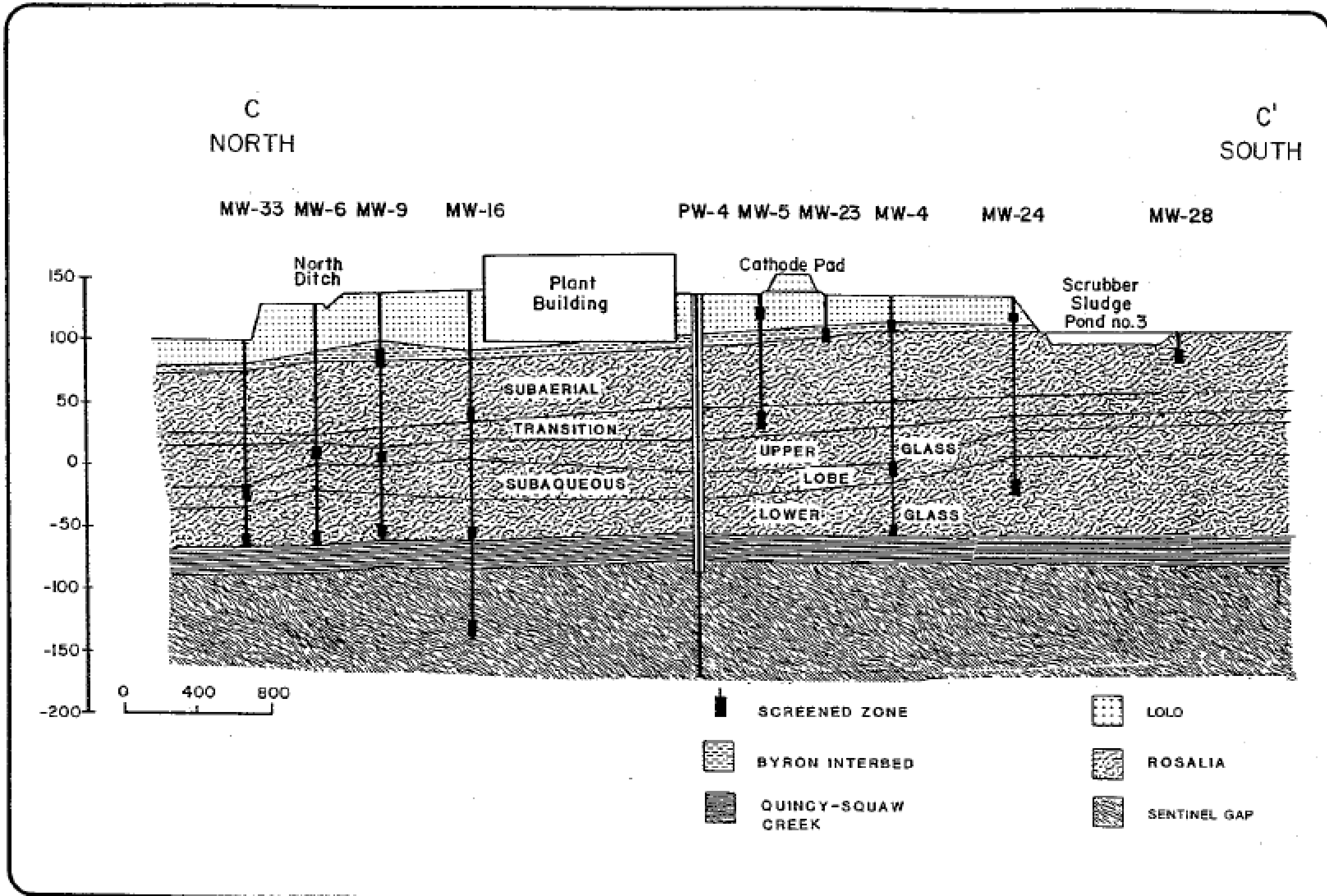


Figure 2-7 Cross-Section D – D’

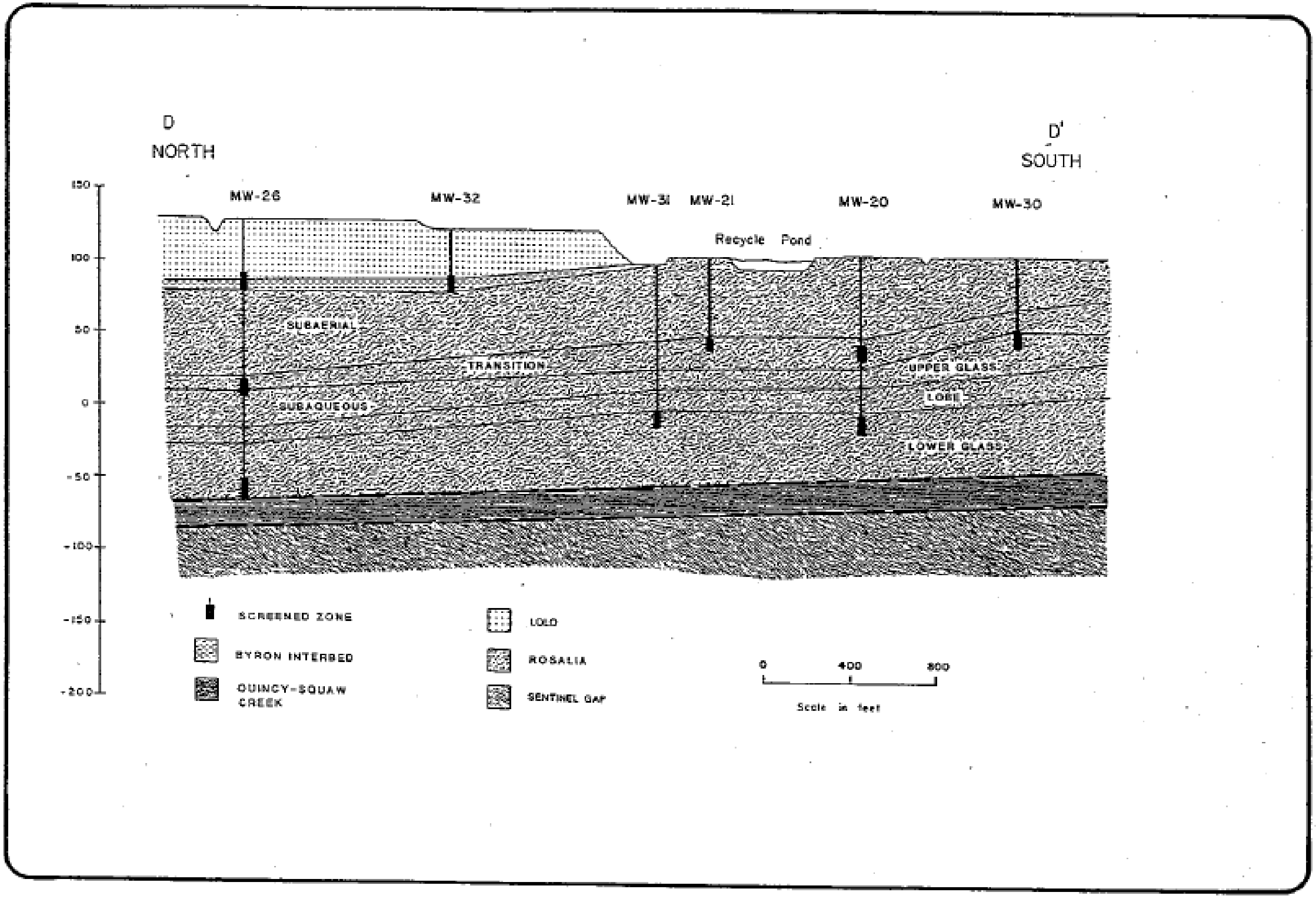


Figure 2-8 Cross-Section E – E’

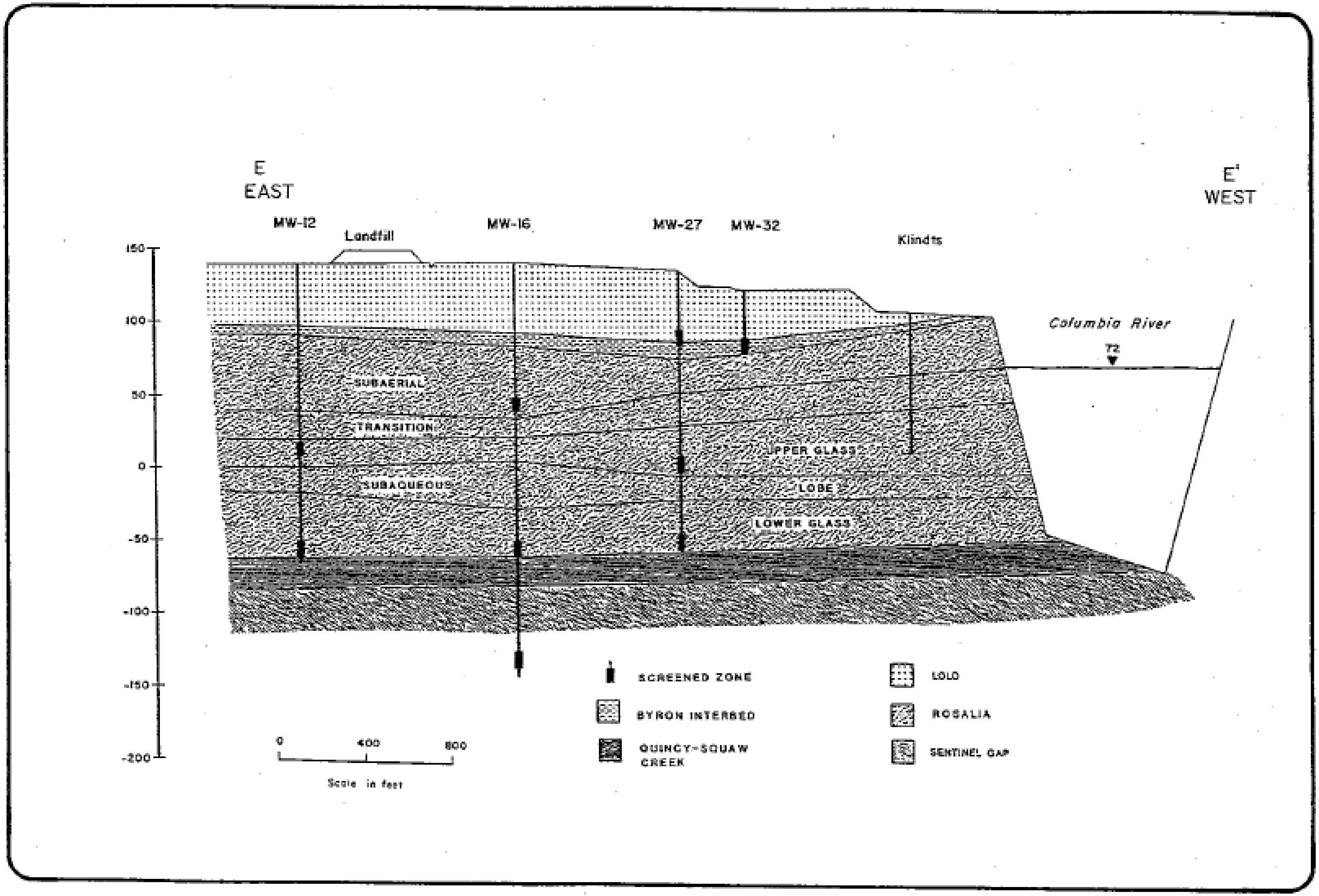


Figure 2-9 Cross-Section F – F’

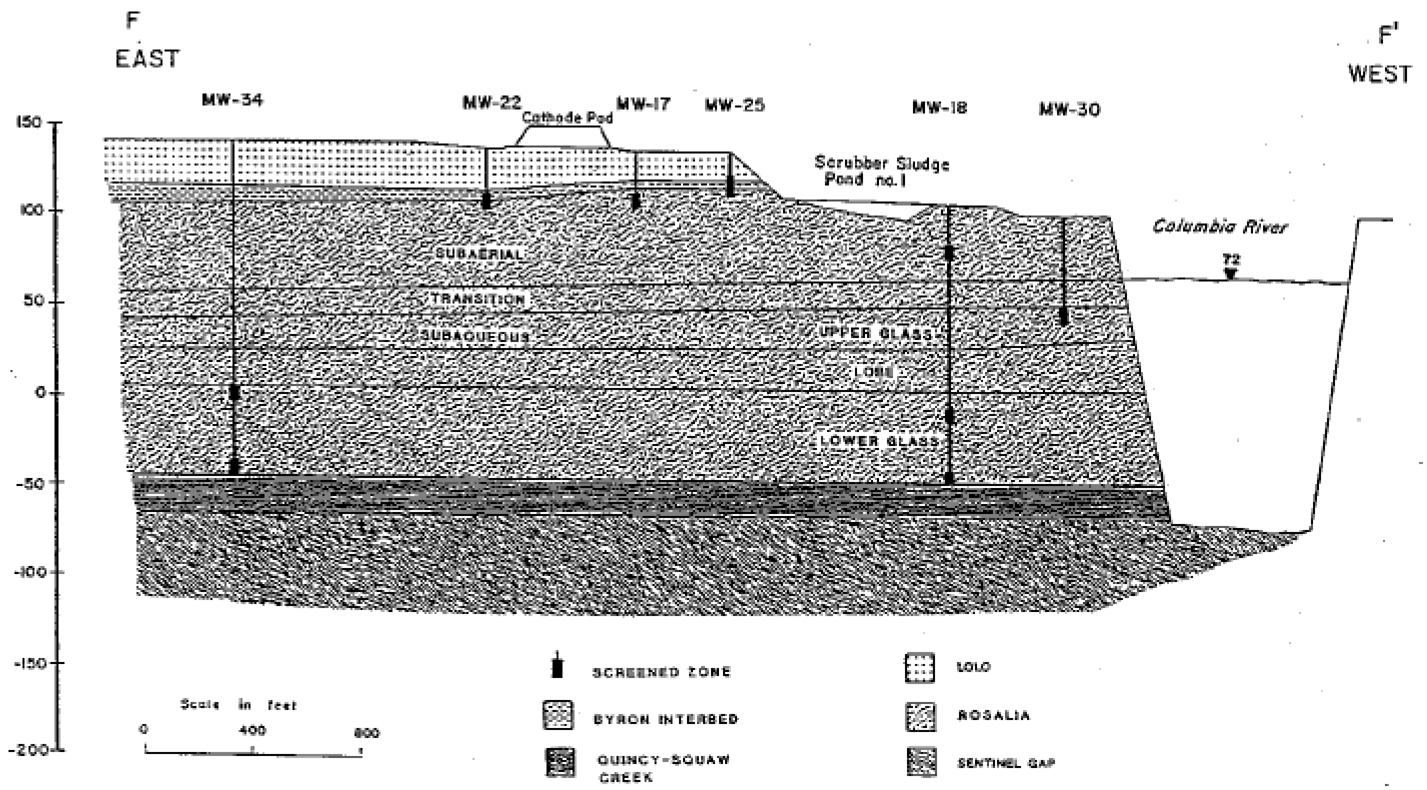


Figure 2-10 Cross-Section showing vertical gradients at Well Clusters

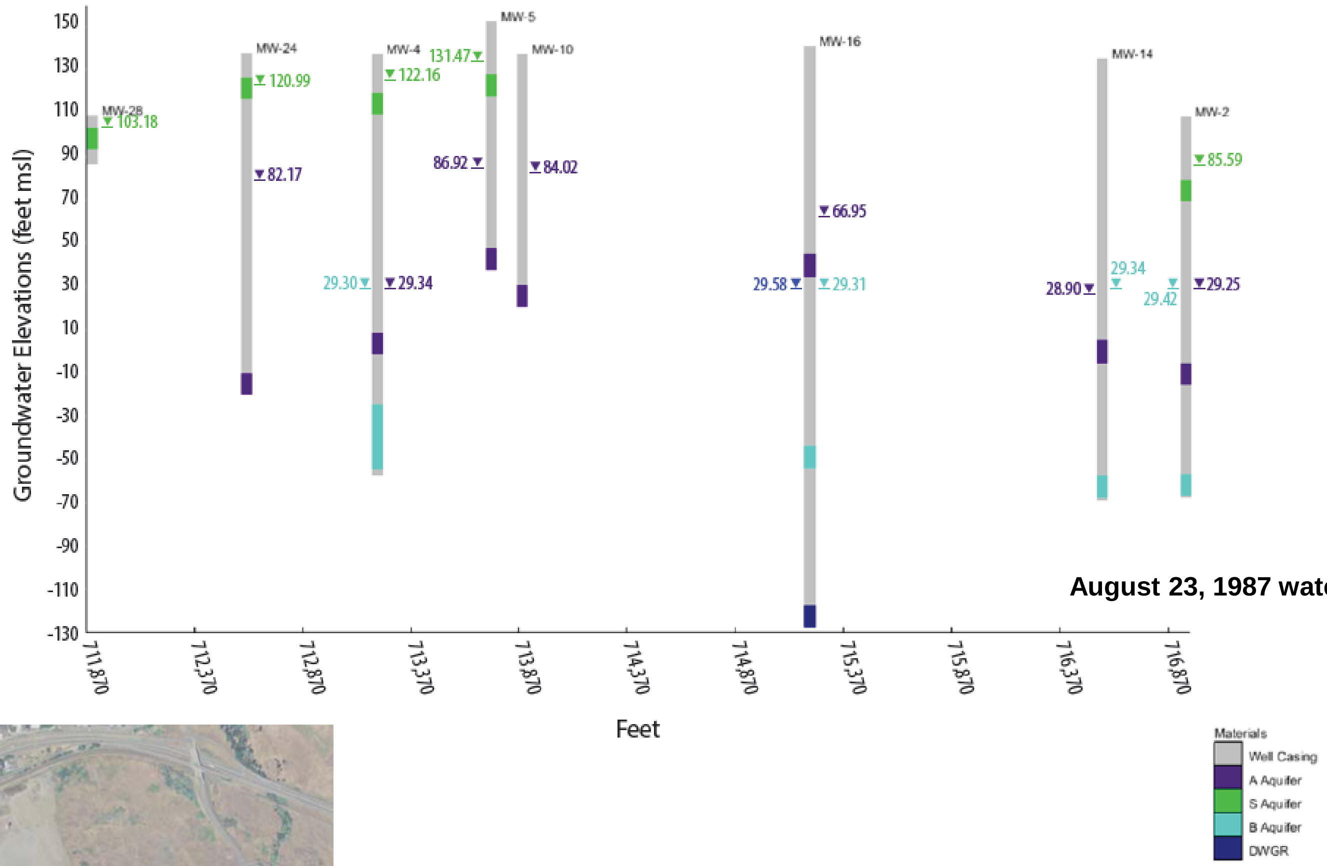


Figure 2-11 S Aquifer Potentiometric Surface

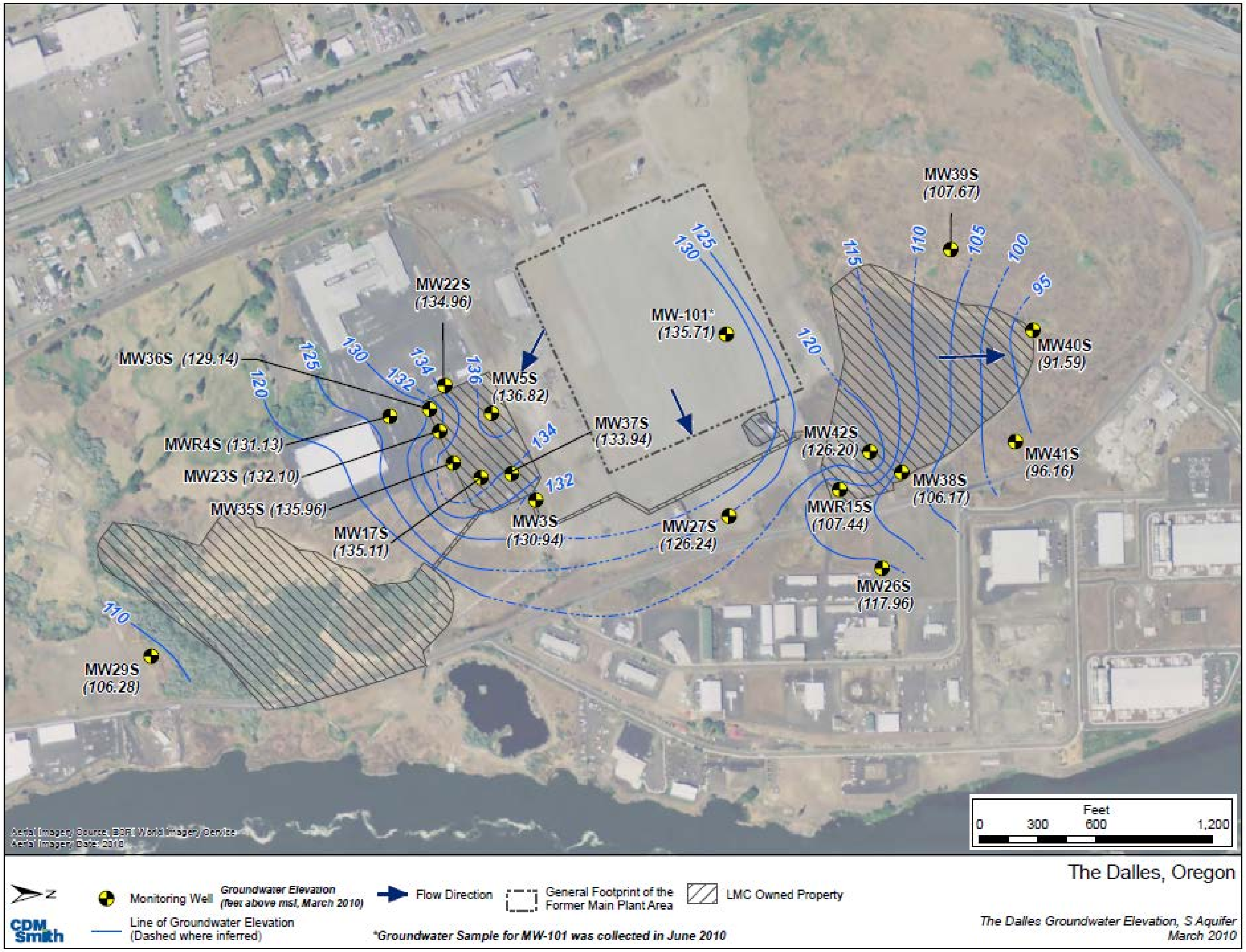


Figure 2-12 A Aquifer Potentiometric Surface

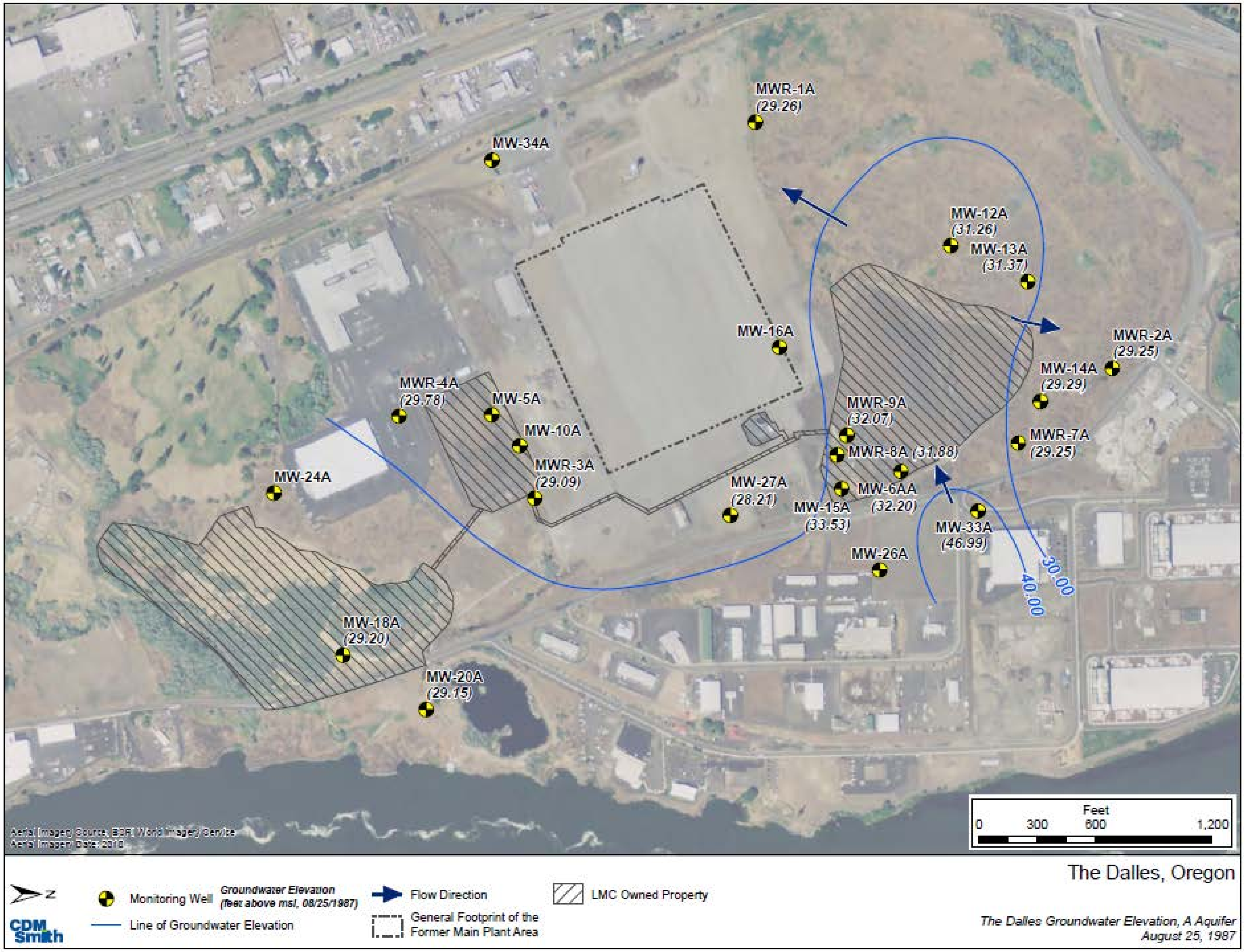


Figure 2-13 B Aquifer Potentiometric Surface

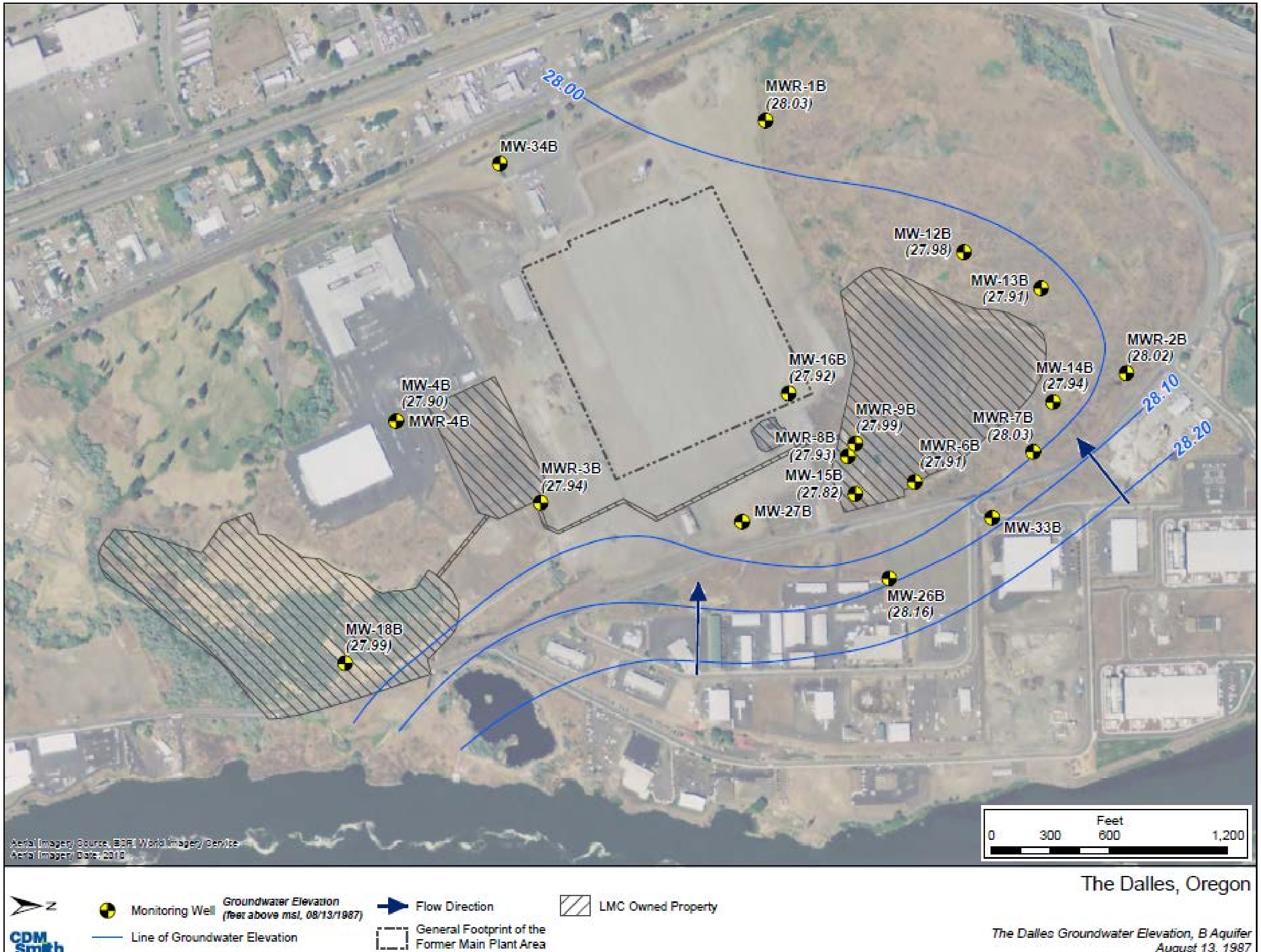
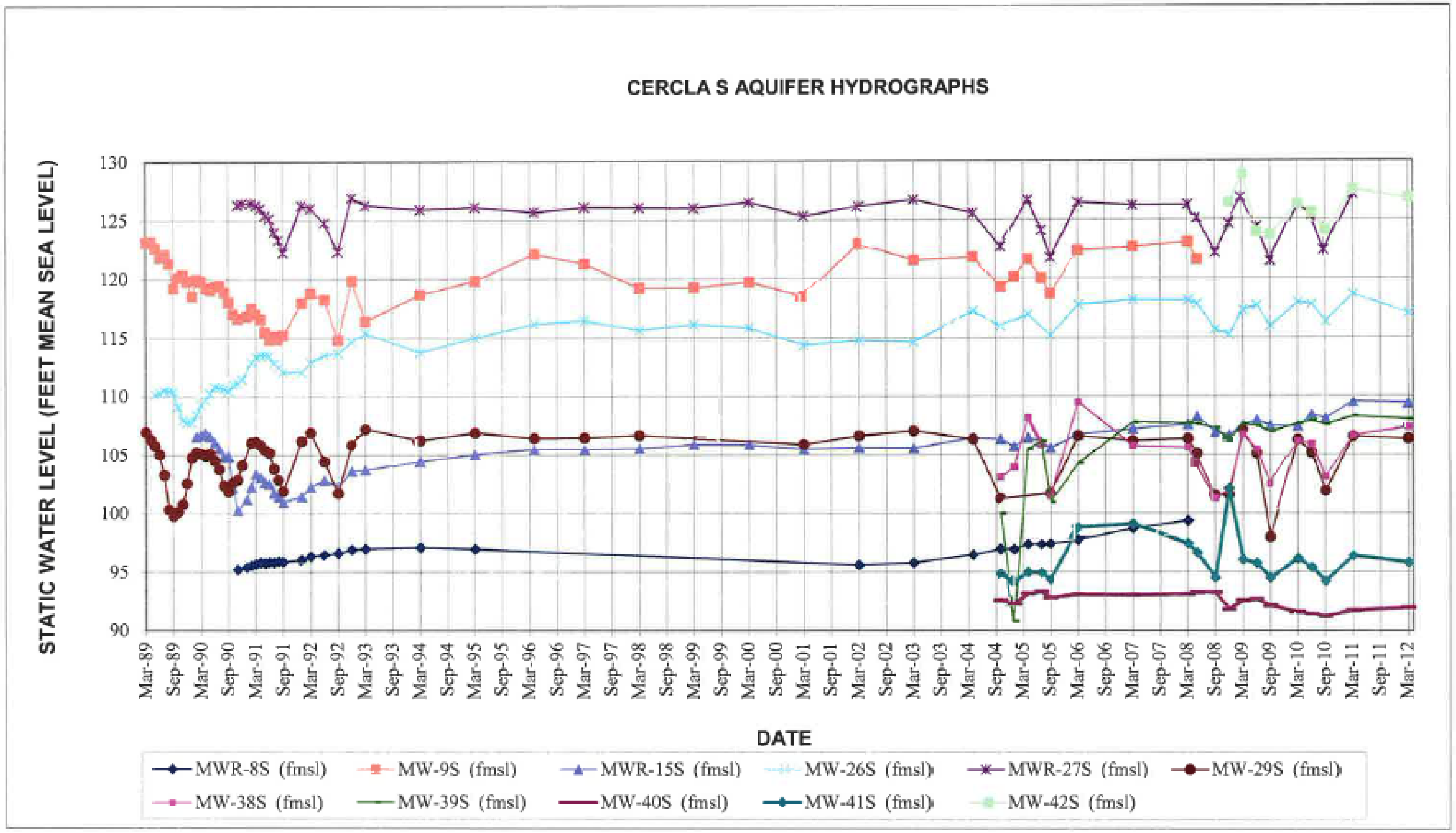


Figure 2-14 S Aquifer Water Level Fluctuations Near the CERCLA Landfill

Chart 4a. CERCLA GROUNDWATER HYDROGRAPHS - S AQUIFER
LOCKHEED MARTIN CORPORATION SITE, THE DALLES, OREGON



Notes: MWR-8S: Water level data not available 1996, 1997, 1998, 1999, 2000 and 2001 (water level below top of pump).
MWR-8S and MW-9S: Abandoned in Fall of 2008 during removal of Landfill Cells MWR-8S and MW-9S.
MW-29S: 1999 begin periodic monitoring.
MW-38S, MW-39S, MW-40S, and MW-41S: Installed September, 2004, outside the CERCLA Landfill site boundary to further characterize potential impacts to the S Aquifer.
MW-42S: Installed in November, 2008, as a replacement for abandoned wells MWR-8S and MW-9S.

Figure 2-15 A and B Aquifer Water Level Fluctuations Near the CERCLA Landfill

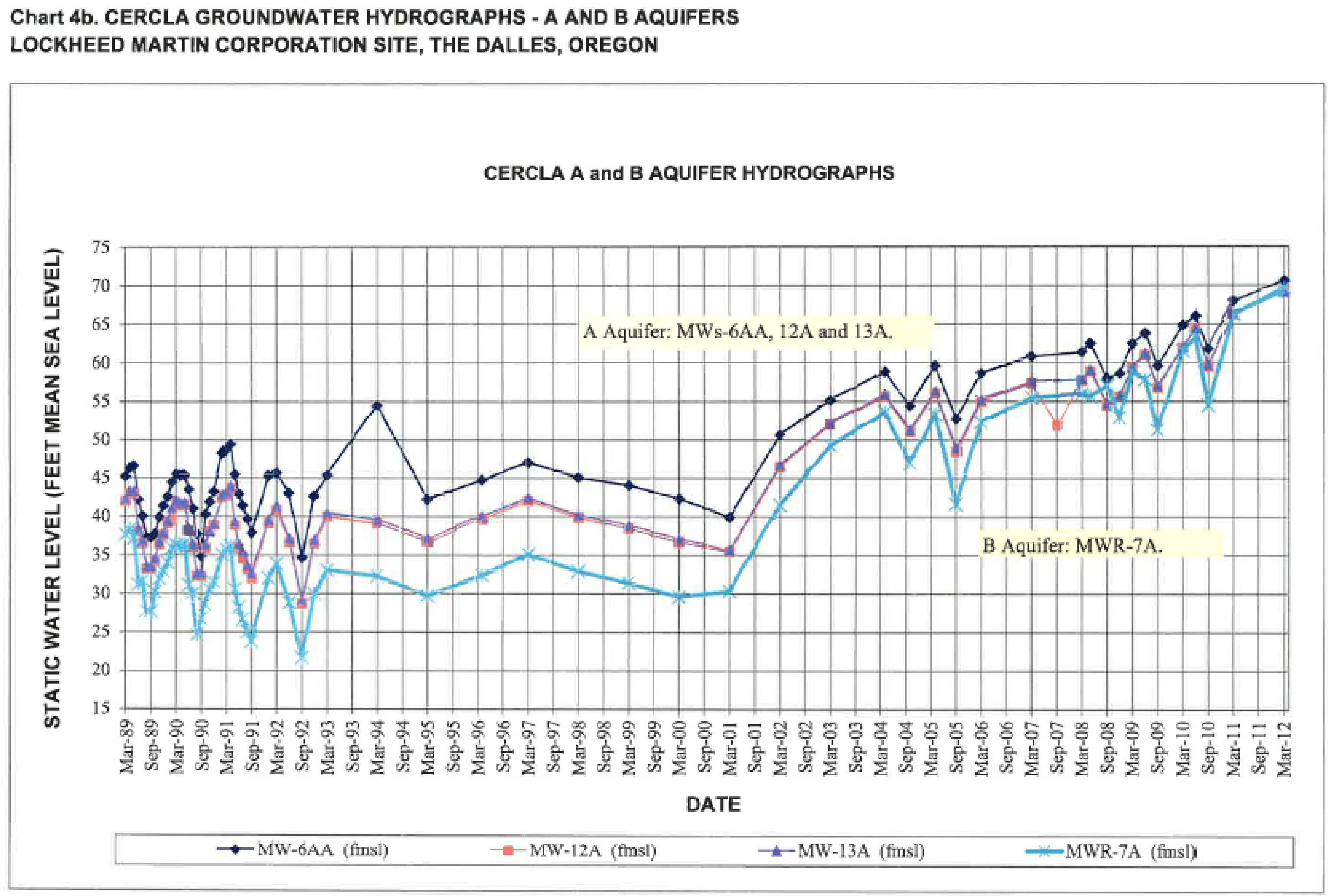


Figure 2-16 Historical Fluoride Extent – All Aquifers

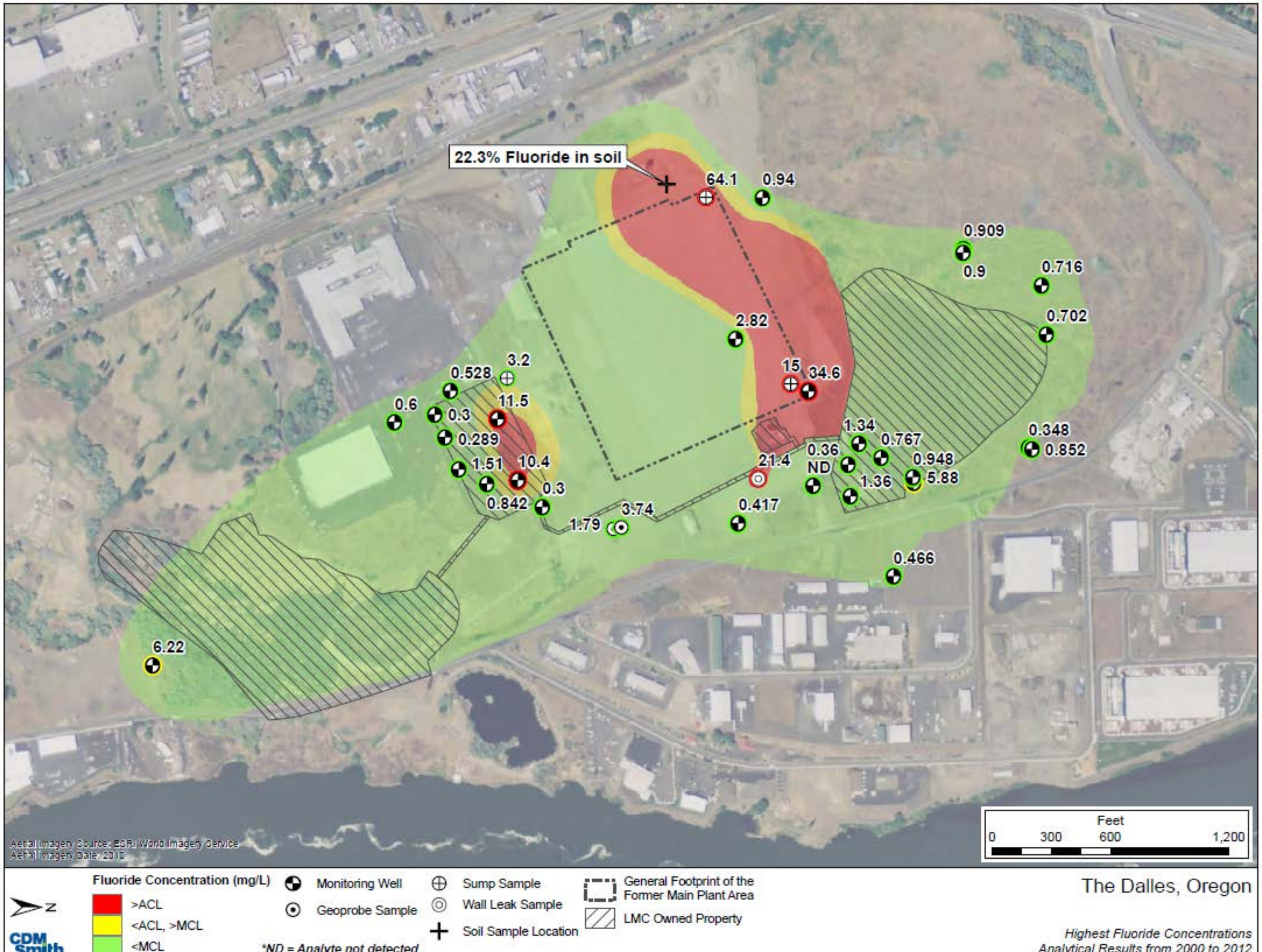


Figure 2-17 March 2012 Fluoride Results – All Aquifers

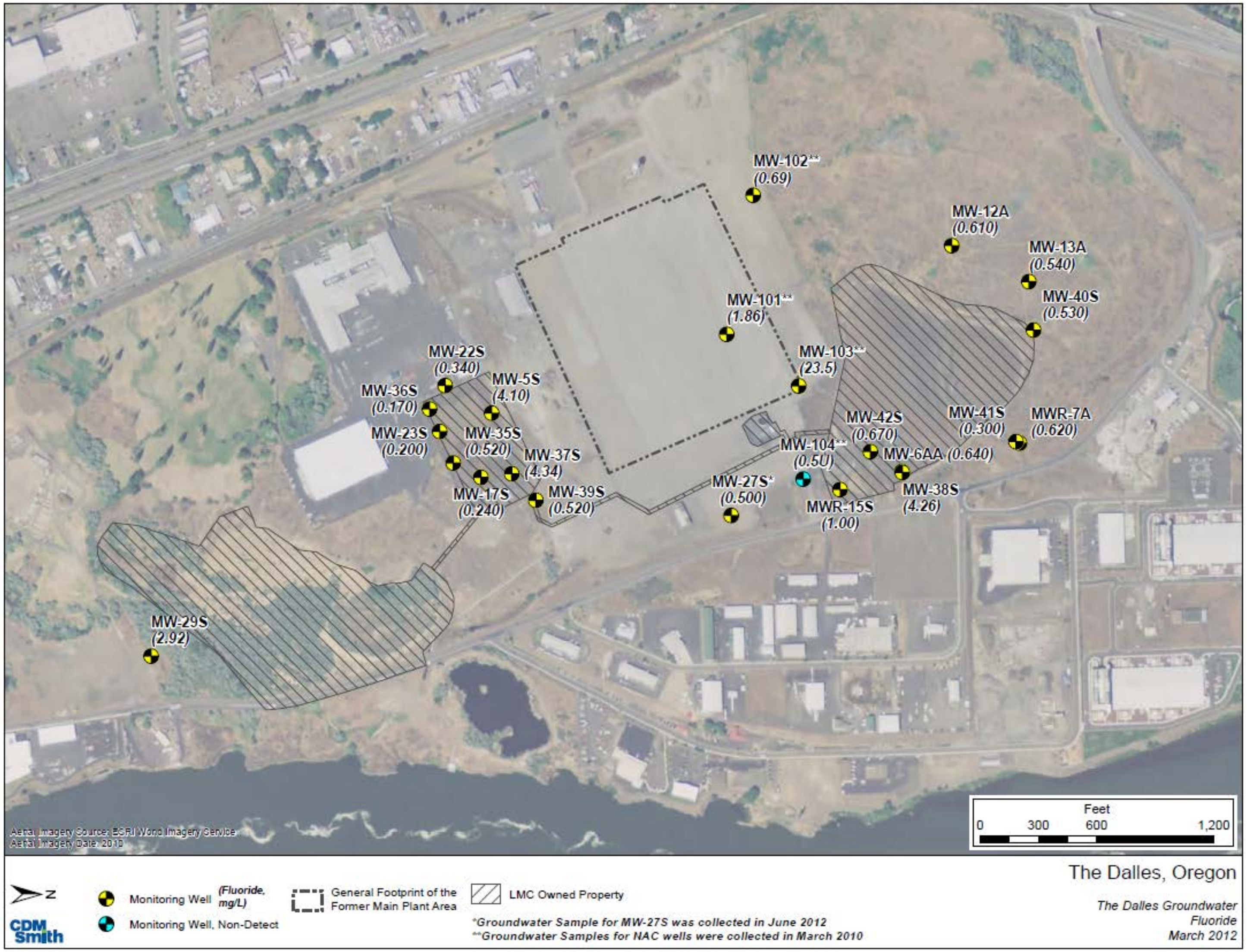


Figure 2-18 Historical WAD or Free Cyanide Results – All Aquifers

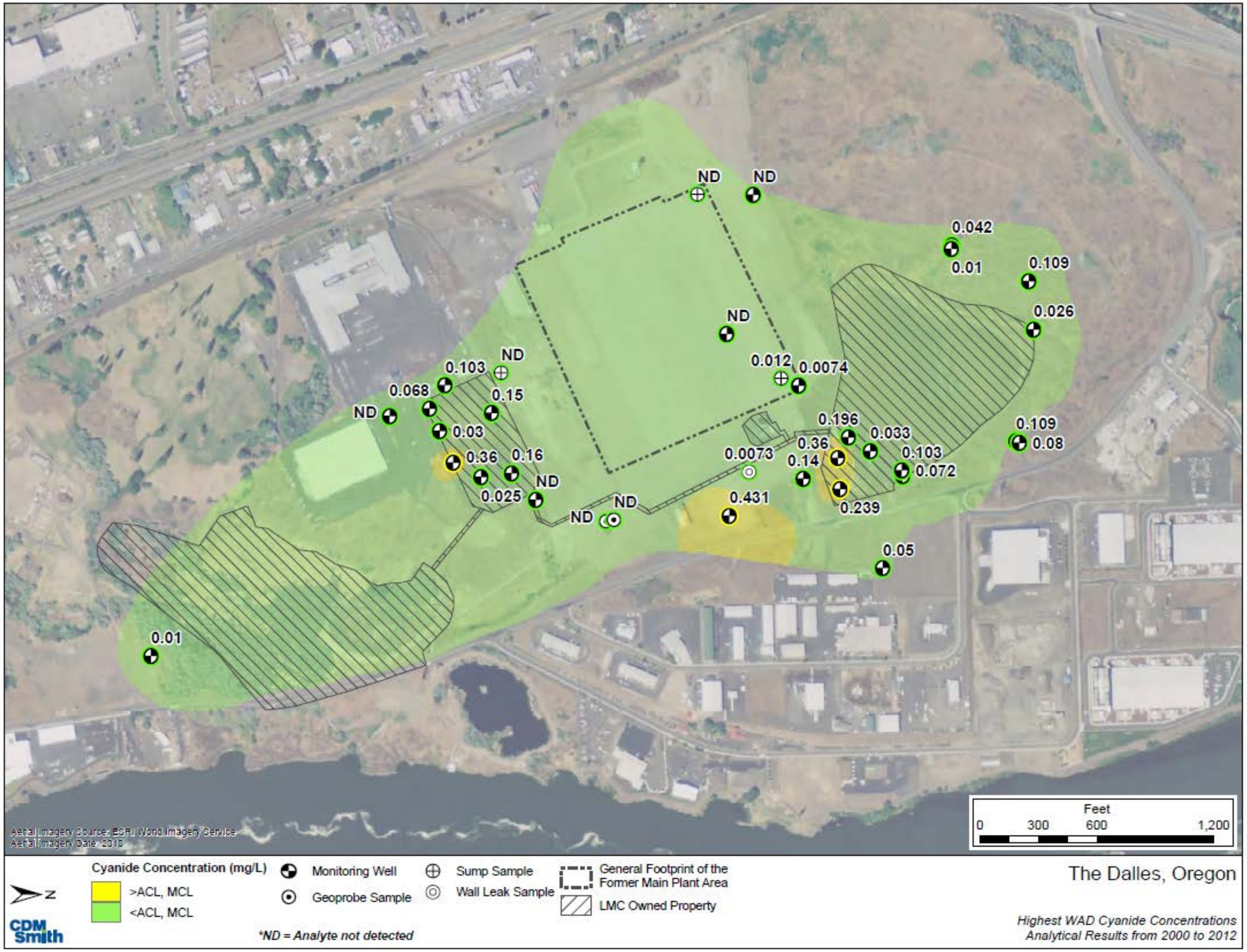
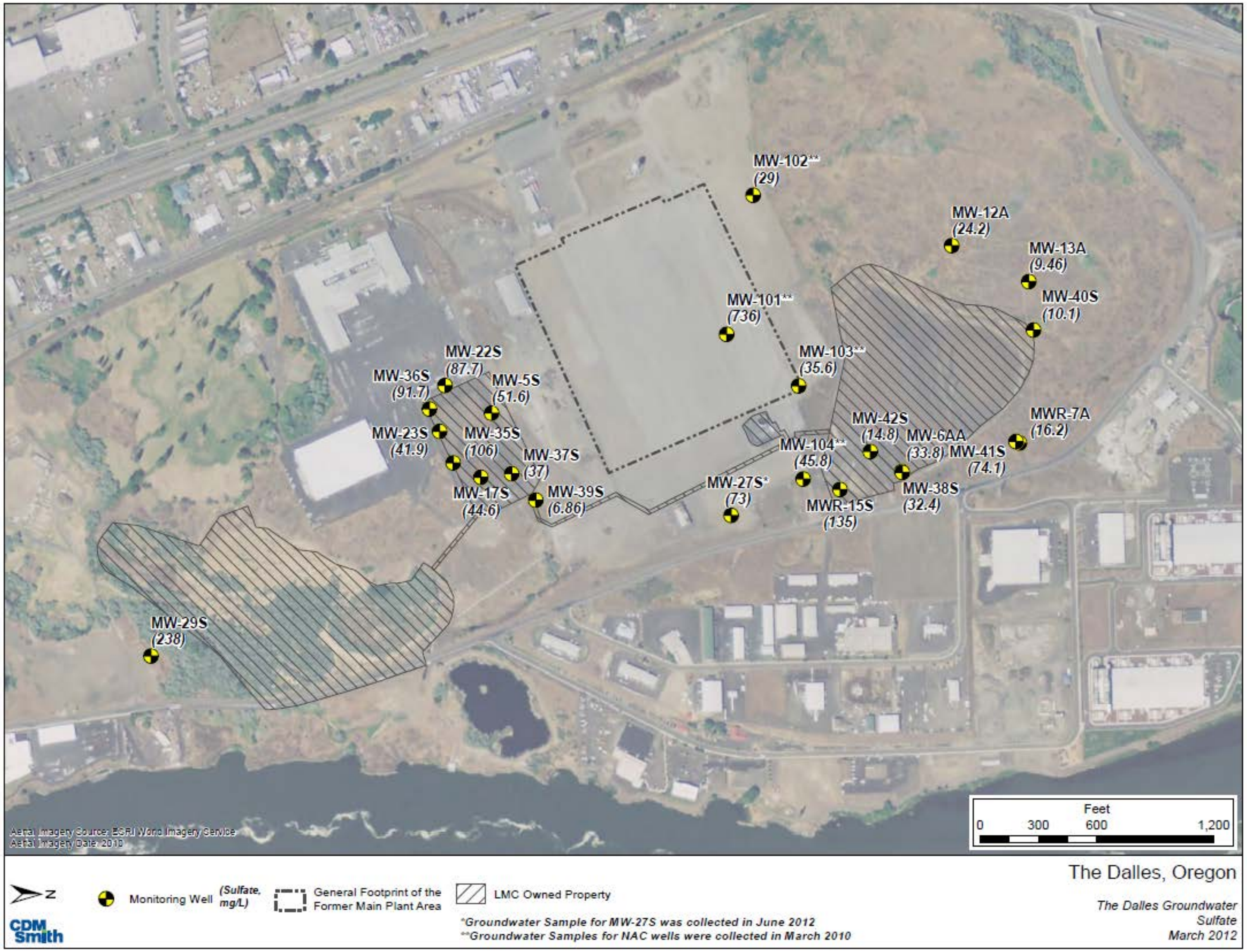


Figure 2-19 March 2012 Sulfate Results – All Aquifers



N

Abandoned Monitoring Well

Existing Monitoring Well

General Footprint of the Former Main Plant Area

LMC Owned Property

CDM Smith

The Dalles, Oregon

Figure 2-20
S Aquifer Monitoring Wells

N

Abandoned Monitoring Well

Existing Monitoring Well

General Footprint of the Former Main Plant Area

LMC Owned Property

CDM Smith

The Dalles, Oregon

Figure 2-21
A Aquifer Monitoring Wells

CDM Smith

The Dalles, Oregon

Figure 2-22
B Aquifer Monitoring Wells

N

Abandoned Monitoring Well

Existing Monitoring Well

General Footprint of the Former Main Plant Area

LMC Owned Property

CDM Smith

The Dalles, Oregon

Figure 2-23
DGWR Monitoring Wells